# UNITARY BRUSH HAVING ABRASIVE COATED BRISTLES AND METHOD OF MAKING THE SAME

## Related Application

This Application is a continuation-in-part of Application Serial No. 09/690,550, filed October 17, 2000.

## Field Of The Invention

The present invention relates to a unitary brush (such as a cup brush, for example) that has abrasive particles secured to at least some of its bristles and to a method of making the brush.

## Background Of The Invention

Rotary brushes are known in the abrasive art. Such brushes are used to clean, abrade, and polish surfaces; to remove coatings; and to prepare surfaces for subsequent processing. Rotary brushes are especially useful to clean abutted joints in sheet metal structures, such as, for example, automotive body panel assemblies, where the flexible bristles are able to operate in recessed seam areas (where the sheet metal is out-of-plane) without significantly rounding or otherwise deforming adjacent (in-plane) sheet metal. Such articles are exemplified by brush assemblies that include metallic wire or abrasive-filled polymeric bristles. Composite or sheath-core bristle brush structures are also known. U.S. Patent No. 5,737,794 (Barber et al.) describes composite abrasive bristles. U.S. Patent No. 5,443,906 (Pihl et al.) describes abrasive filaments comprising thermoplastic elastomers. The bristles of such brushes may be oriented to extend radially or perpendicularly from a driven base structure. Brushes that have bristles that extend radially are frequently referred to as radial brushes. Brushes that have bristles that extend perpendicularly from a base are frequently referred to as right angle brushes.

Unitary brushes are characterized by having a hub or body portion comprised of the same composition as the bristles in a one-piece structure. That is, the hub or body and the bristles attached to the body are formed from the same mass of material at the same time without adhesive bonding or mechanical fastening of bristles to the hub or body portion. Such brushes are valued because they have excellent bristle anchoring with no concern of bristle loss caused by adhesive or mechanical fastener failure.

One type of unitary brush is an injection molded brush. Injection molded bristle brushes are described in U.S. Patent Nos. 5,915,436 and 5,903,951 (Johnson et al.). These articles have the advantages of providing design flexibility and control of bristle orientation during use. Other types of unitary brushes are made by cutting, e.g., from a sheet, a shaped hub bearing a radial array of bristle projections and either using a single shape as a brush or stacking a multiplicity of such shapes until a unitary stack is obtained and attaching the shapes together mechanically or with adhesive.

## Summary Of The Invention

There remains a need to provide a brush having the design flexibility of a unitary brush but with increased performance as an abrasive article. The invention provides:

(a) a unitary brush, the brush having a plurality of bristles, each bristle having a surface;

(b) a first coating over at least a portion of at least some of the bristle surfaces; and

(c) a plurality of abrasive particles secured to at least a portion of at least some of the bristle surfaces via the first coating.

In a further embodiment, a second coating is included over the abrasive particles and first coating.

The invention further provides a method of making an abrasive brush, said method comprising:

(a) providing a unitary brush comprised of a base portion formed of a material and a plurality of bristles comprised of the same material extending therefrom and wherein each bristle has a surface;

(b) coating at least a portion of the surfaces of at least a portion of the bristles with a first coating;

(c) adhering a plurality of abrasive particles to at least some of the bristle surfaces via the first coating; and

(d) curing the first coating to adhere the abrasive particles to the bristle surfaces.

In a further embodiment, a second coating is applied over the abrasive particles and first coating and the second coating is cured.

The term "unitary brush" shall mean any brush that is comprised of a hub or body and bristles which are attached to the body or hub and are formed of the same mass of material as the hub or body without adhesive bonding or mechanical fastening of bristles to the hub or body portion. Exemplary unitary brushes are injection molded or formed of an individual cut segment or a stack of cut segments of sheet material that are die cut, water jet cut, or laser cut to form single segments of hub portions bearing a plurality of bristles.

The unitary brushes are preferably injection molded rotary brushes and are preferably rotatable about an axis. Preferably, they are designed to be attached to a rotary tool such as an electrical or pneumatic tool.

The novel abrasive article of the invention comprising a unitary brush has a number of advantages including a broader range of abrasive performance, design flexibility and brush-making efficiency.

## Brief Description Of The Drawings

Fig. 1a illustrates a front plan view of an embodiment of an article of the invention.

Fig. 1b illustrates a central cross-section taken through one of the bristles of the article of Fig. 1a.

Fig. 2 illustrates an isometric view of another embodiment of an article of the invention.

Fig. 3a illustrates a side view of another embodiment of an article of the invention.

Fig. 3b illustrates a central cross-section taken through one of the bristles of the article of Fig. 3a.

## Detailed Description Of The Invention

## Abrasive Particles

Abrasive particles used in the article of the invention may be organic, inorganic, or a composite of one or both of the aforementioned. Abrasive particle composition, concentration, and size are chosen according to the nature of the intended workpiece surface and the desired effect of the abrasive coated unitary brush on the workpiece surface. Suitable inorganic particles include, but are not limited to, those selected from the group consisting of silicon carbide, talc, garnet, glass bubbles, glass beads, cubic boron nitride, diamond, and aluminum oxide, including ceramic aluminum oxide such as that available under the trade designation CUBITRON abrasive from Minnesota Mining and Manufacturing Company, St. Paul, Minnesota. Suitable organic abrasive particles include, but are not limited to, those of comminuted thermoplastic and/or thermosetting polymeric materials. Composite abrasive particles include, but are not limited to, agglomerates comprising inorganic particles adhered in an organic polymeric or ceramic binder. Precisely shaped abrasive particles may also be employed. Sizes of useful abrasive particles typically vary from mean particle diameters of about 0.1 to about 1000 micrometers, more typically about 100 to about 500 micrometers. The mean particle diameter is typically about 1/10 to about 1 times the mean bristle diameter, more typically about 1/5 to about 1/2 times the mean bristle diameter.

## First Coating

The first coating which is used to secure the abrasive particles to the bristles preferably provides good attachment adhesion or bond to both the bristles and the abrasive particles and demonstrates wear and flexibility properties similar to that of the bristles. Coatings may be borne in organic or aqueous solutions or dispersions or may be 100% solid materials such as thermoplastic polymeric materials. The first coating is preferably an adhesive. The first coating preferably comprises a curable organic material (i.e., a monomer, oligomer, or material capable of polymerizing and/or crosslinking upon exposure to heat and/or other sources of energy, such as ultraviolet light, visible light, etc., or with time upon the addition of a chemical catalyst, moisture, or other agent which causes the material to cure or polymerize). Representative coating examples include crosslinkable materials such as phenolic resins, bismaleimide resins, vinyl ether resins, aminoplast resins

having pendant alpha, beta unsaturated carbonyl groups, urethane resins, epoxy resins, polyurethane resins, acrylate resins, acrylated isocyanurate resins, urea-formaldchyde resins, isocyanurate resins, and mixtures thereof. Other representative materials the first coating may comprise those selected from the group consisting of amino polymers or aminoplast polymers such as alkylated urea-formaldehyde polymers, melamineformaldehyde polymers, and alkylated benzoguanamine-formaldehyde polymers; acrylate polymers including acrylates and methacrylates, alkyl acrylates, acrylated polyesters, acrylated polyethers, vinyl ethers, acrylated oils, and acrylated silicones; alkyd polymers such as urethane alkyd polymers; polyester polymers; reactive urethane polymers; phenolic polymers such as resole and novolac polymers; phenolic/latex polymers; epoxy polymers such as bisphenol epoxy polymers; isocyanates; isocyanurates; polysiloxane polymers including alkylalkoxysilane polymers; and reactive vinyl polymers. The resulting first coating may be in the form of monomers, oligomers, polymers, or combinations thereof.

In addition to thermosetting polymers, thermoplastic polymers may also be used. Examples of suitable thermoplastic polymers include, but are not limited to, polyamides, polyethylenes, polypropylenes, polyesters, polyurethanes, polyetherimides, polysulfones, polystyrenes, acrylonitrile-butadiene-styrene block copolymers, styrene-butadiene-styrene block copolymers, styrene-isoprene-styrene block copolymers, acetal polymers, polyvinyl chlorides, and combinations thereof.

In the case of a first coating containing ethylenically unsaturated monomers and oligomers, polymerization initiators may be included Representative examples include organic peroxides, azo compounds, quinones, nitroso compounds, acyl halides, hydrazones, mercapto compounds, pyrylium compounds, imidazoles, chlorotriazines, benzoin, benzoin alkyl ethers, diketones, phenones, mixtures thereof, and the like.

A suitable initiator system may also include a photosensitizer. Representative photosensitizers may have carbonyl groups, tertiary amino groups, or combinations thereof. Preferred photosensitizers having carbonyl groups are benzophenone, acetophenone, benzil, benzaldehyde, *o*-chlorobenzaldehyde, xanthone, thioxanthone, 9,10-anthraquinone, and other aromatic ketones. Preferred photosensitizers having tertiary amino groups are methyldiethanolamine, ethyldiethanolamine, triethanolamine, phenylmethyl-ethanolamine, and dimethylaminoethylbenzoate.

In general, the amount of photoinitiator may vary from about 0.01 to about 10 percent by weight, more preferably from about 0.25 to 4 percent by weight of the first coating. Additionally, it is preferred to disperse (preferably uniformly) the initiator in the first coating before addition of any particulate material, such as filler particles.

Cationic initiators may be used to initiate polymerization when the first coating is based upon an epoxy resin or vinyl ether functional resin. Examples of cationic initiators include salts of onium cations, such as arylsulfonium salts, as well as organometallic salts such as ion arene systems. Other examples are reported in U.S. Pat. Nos. 4,751,138 (Tumey et al.); 5,256,170 (Harmer et al.); 4,985,340 (Palazotto); and 4,950,696 (Palazotto et al.) all incorporated herein by reference.

The first coating may further comprise an additive including but not limited to those selected from the group consisting of fillers, pigments, lubricants, and grinding aids.

A preferred coating composition in accordance with the present invention comprises 70.37 parts by weight polyurethane (e.g., that available under the trade designation ADIPRENE BL-16 polyurethane from Uniroyal Chemical Ltd., Elmira, Ontario, Canada), 19.54 parts by weight curative (e.g., 4,4' –diaminobenzanilide, commercially available from Biddle Sawyer Corporation, New York, New York); 4.04 parts by weight lubricant (e.g., that available under the trade designation "PM" lithium stearate, commercially available from Witco Corporation, Greenwich, Connecticut); 5.65 parts by weight solvent (e.g., that available under the trade designation ARCOSOLV PM Acetate propylene acetate monomethyl ether acetate, commercially available from Arco Chemical Company, Houston, Texas) and 0.5 part by weight silica fume (e.g., that available under the trade designation CAB-O-SIL from Cabot Corporation, Tuscola, Illinois).

The thickness of the first coating can vary. The thickness of the first coating is dependent upon a number of factors such as the size and amount of the abrasive particles used. The dry weight of the first coating on a brush depends on the brush size, and typically ranges from about 0.01 to about 100 grams per brush. For example, the first coating on a 3" (7.6 cm) bristle brush sufficient to adhere ANSI grade 36 silicon carbide particles will typically have a dry weight of between about 0.1 and about 10 grams. Typically the first coating is thick enough to adhere the abrasive particles to the bristles but not so thick as to engulf the abrasive particles. The first coating thickness is typically

proportional to the abrasive particle diameter (i.e. largest dimension). Typically the first coating thickness is about 25 to about 70 percent of the abrasive particle diameter, more typically about 40 to about 60 percent.

## Second Coating

The article of the invention in one embodiment further comprises a second coating which is coated over the abrasive particles and the first coating to the extent which it may be exposed. The second coating preferably demonstrates good adhesion to the abrasive particles and to the first coating and wears away as the abrasive particles wear away. Preferably, the second coating has a minimal propensity to transfer from the abrasive article to the workpiece under use conditions.

The second coating may comprise the same materials as the first coating described above. The second coating is preferably an adhesive. The second coating may be the same composition or a different composition as the first coating. For some embodiments it may be preferred to provide a second coating composition similar or identical to the first coating composition in order to provide good adhesion between the coatings and to provide flexibilities compatible with the unitary bristles. For other embodiments, however, it may be preferred to provide a second coating composition which is harder and more abrasion resistant than the first coating composition.

The thickness of the second coating may vary. The thickness of the second coating is dependent upon a number of factors such as the size and amount of the abrasive particles used. Typically the second coating is thick enough to reinforce the attachment adhesion or bond of the abrasive particles to the first coating but not so thick as to obscure the abrasive texture of the coated bristle. The second coating thickness is typically proportional to the abrasive particle diameter (i.e. largest dimension). Typically the second coating thickness is about 10 to 40 percent of the abrasive particle mean diameter, more typically about 20 to about 40 percent.

## Brush Type and Usage

The unitary brushes which are coated to provide the abrasive article of the invention, as previously mentioned, can be any brush which has a hub or base portion and

bristles or filaments extending from the hub or base portion made of the same material which forms the hub or base portion in one piece. That is, the bristles are not adhesively or mechanically fastened to the hub or base portion, but instead they are either injection molded, molded by some other process (cast, compression molded, etc.), or they are formed by cutting segments from a sheet of material such as a plastic film forming a base portion segment which bears bristles having the desired deployment. Such segments may be laser cut, water jet cut, die cut or mechanically cut. Such segments may then be used singly or stacked and mechanically fastened or adhesively bonded together so that the individual segments form a stacked structure with the bristles deployed outward from the hub as desired. Mechanical fastening may be accomplished by utilizing suitable clamps that are readily commercially available or by utilizing a suitable adhesive bonding material which is, likewise, commercially available. The stacked segments may be stacked directly on one another or they may be separated by a spacer hub portion which bears no bristles to provide space between bristles deployed along the hub. A common characteristic of the bristles in a unitary brush is the fact that they are composed of the same material as the hub and are formed at essentially the same time the hub is formed.

The abrasive-coated unitary brushes of the invention can be any one of many types and for a myriad of uses, such as, for example, cleaning, coating removal, deburring, radiusing, and imparting decorative finishes onto any of a variety of substrates such as metal, plastic, glass, wood, and the like. Preferably, the brush of the invention readily conforms to the contours of a workpiece. Preferably, the brush of the invention readily sheds detritus (i.e., does not "load") and has a high cutting rate.

Typically, the unitary brush comprises a generally planar base having a first side and a second side, the base having a plurality of bristles extending from the sides. The bristles are integrally formed with the base.

One type of unitary brush has bristles that extend from the first side of the base. This type of brush is commonly known as a cup brush, end brush, or right-angle brush, and is typically driven by a right-angle tool. Such unitary brushes are conveniently made by one of the molding techniques cited above.

Another type of unitary brush has bristles that extend from the outer peripheral edge between the first side and the second side of the base. Such brushes are commonly known

as radial brushes, wheel brushes, or cylinder brushes. This type of unitary brush may be made by the previously described molding or cutting techniques.

The material which the brush, including the bristles, comprises may vary and its selection depends on any of a number of different factors such as, for example, its ability to adhere to a coating, its ability to sustain the desired rotational speed, and its ability to sustain wear similar to that of the coating(s). The brush, including the bristles, can comprise any of a number of different materials, including, but not limited to, moldable polymers including polyamides, polyolefins, polyesters, thermoplastic elastomers, poly(ether imides), polysulfones, polyaramids, and the like. Typically the brush, including the bristles, comprises a material selected from the group consisting of polyesters, polyolefins, polyamides, and thermoplastic elastomers.

The design of the unitary brush may contribute to the successful use of the article of the invention. Design features such as bristle length, bristle cross section, and bristle curvature may affect the function and performance of the brush. The bristle length is preferably sufficiently long to allow for good life, but not so long as to contribute to bristle fracture when operated at high speeds. Typically the ratio of average bristle length to average bristle diameter for a radial brush ranges from about 3:1 to about 100.1, more typically about 5:1 to about 30:1. Typically the ratio of average bristle length to average bristle diameter for a cup brush ranges from about 3:1 to about 50:1, more typically about 5:1 to about 20:1.

In one embodiment, the brush, including the bristles, may further comprise abrasive particles which are contained within the brush and/or bristles. In another embodiment, the unitary brush including the bristles, may further comprise one or more additives such as those selected from the group consisting of lubricants, colorants, coupling agents, compatibilizers, mold release agents, nucleating agents, and the like.

Method of Making the Article

The amount of surface area of the bristles which has abrasive particles secured thereto may vary depending upon a number of factors such as, for example, the nature of the surface to be abraded, the expected life of the abrasive article, and the design of the brush. The abrasive particles are typically applied over substantially the entire surface of

the bristles although in some circumstances it may be desirable to have the abrasive particles attached to only a portion of the bristles. The concentration of the abrasive particles on the bristles of the brush may also vary. For some applications it may be desirable to have a high concentration of abrasive particles on the bristles. For other applications it may be desirable to have a lower concentration of abrasive particles on the bristles. Typically, the amount of the bristle surface covered with abrasive particles ranges from about 10 to about 100 percent, more typically about 50 to about 100 percent, and most typically about 90 to about 100 percent.

The article of the invention may be made as follows, for example. First, a unitary brush is provided. Next, a first coating is applied to at least a portion of at least some of the bristles, preferably all of the bristles. Preferably the first coating is applied to the entire surface of at least some of the bristles, more preferably all of the bristles. The first coating may be applied by any of several different methods including, but not limited to, roll coating, spray coating, "dip and spin" methods, etc. The phrase "dip and spin" refers to dipping the bristles in the coating and spinning the brush to remove excess coating from the bristles. Next, abrasive particles are applied to the first coating. This can be done by any of a number of different methods including, but not limited to, spray coating, drop coating, fluidized bed coating, and/or electrostatic coating. This is followed by a step of curing or hardening the first coating, thereby securing the abrasive particles to the coated unitary brush. This step can be achieved by heating to dry and/or polymerize the coating, by the application of radiation energy (such as ultraviolet radiation, for example), by allowing atmospheric moisture to crosslink the coating, or by cooling a thermoplastic coating. This is followed, for some embodiments, by an additional step of applying a second coating over the abrasive particles and first coat followed by curing or hardening the second coating, thereby further securing the abrasive particles to the bristles. Curing or hardening of the second coating may be achieved by heating to dry and/or polymerize the coating, by the application of radiation energy or atmospheric moisture to crosslink the coating, or by cooling a thermoplastic coating.

This invention will be better understood by referring to the following figures.

Fig. 1a illustrates a front plan view of an embodiment of an article of the invention. Article 2 is a radial brush which comprises a central hub 3 having bristles 4 extending

radially therefrom. Central hub 3 has a hole 7 in the center thereof. Bristles 4 have abrasive particles 6 adhered thereto via first coating 8 (shown in Fig. 1b). Second coating 10 is applied over the abrasive particles 6 and first coating 8. Fig. lb is a central cross-section taken through one of the bristles of Fig. la.

Fig. 2 is an isometric view of an article 20 of the invention comprising three articles 2 of Fig. 1 secured together via a metal adapter 22 in order to form a larger brush 20.

Fig. 3a is a side view of another embodiment of an article of the invention. The article 24 is a right angle, or cup, brush having a base 26 and bristles 28 attached to the base 26 at a right angle to the base 26. Abrasive particles 30 are adhered to the bristles 28 via first coating 32. The base 26 has a hole 34 in the center thereof. The hole 34 perimeter is threaded to allow for easy attachment to a rotary hand tool, for example. Fig. 3b is a central cross-section taken through one of the bristles of Fig. 3a.

The invention is further illustrated by the following examples wherein all parts and percentages are by weight unless otherwise indicated.

## Examples

Procedure for Injection Molding of Brush

An injection molded radial bristle brush having forty 2.2 cm long integral bristles, a 1.5 inch (3.8 cm) hub, a 3.0 inch (7.6 cm diameter), and a weight of 1.65 grams was molded from polyamide 11 (BESNO P40TL, available commercially from Elf Atochem, Arlington Heights, Illinois). A single-cavity mold was employed. The injection molding machine used was a 220-ton (200,000 kg) clamping force machine from Cincinnati Milacron (Batavia, Ohio), which employed a single shot extruder with a general purpose screw.

Typical molding parameters included: nozzle temperature 232°C (450°F), temperature at the front of the barrel (proximate the nozzle) 216°C (420°F), temperature at the rear of the barrel (proximate the hopper) 232°C (450°F), screw rotation 75% of maximum, 2760-3450 kPa (400-500 psi) injection pressure, and a 2 29 cm (0.90 inch) shot distance or length. A complete cycle time on average was about 20 seconds per injection molded brush.

Example 1

Abrasive coated injection molded radial brushes of the invention were prepared as follows. The adhesive composition used for coating each injection molded brush is reported in Table I. Twelve injection molded polyamide ("BESNO P40TL", available commercially from Elf Atochem) brushes, each prepared according to "Procedure for Injection Molding of Brush,"were mounted on an electrically-driven mandrel with 1.5 inch (3.8 cm) wide and 0.5 inch (1.3 cm) thick TEFLON polytetrafluroethylene spacers between each brush, rotated at about 15 RPM, submerged in the adhesive composition for about 10 seconds while the rotation continued, removed from the adhesive composition, and rotated at about 300 RPM for about 10 seconds to remove excess adhesive. The resultant first coating was applied to achieve a dry add-on weight of 0.3 gram per brush.

The mandrel was transported to a spray booth, where ANSI grade 36 silicon carbide abrasive particles were applied via a spray gun to the wet first coating on each brush. The abrasive particles were applied to both sides of eleven of the brushes until no additional abrasive particles would adhere to the wet first coatings, which was about 2.4 grams of abrasive particles per brush. The abrasive coated brushes were then heated to 130°C for 45 minutes to harden the first coating and secure the abrasive particles to the injection molded brushes. A brush without abrasive particle was also heated under the same conditions. (This brush aided in the calculation of the first coating dry weight.) Following heating, a second coating (having the same composition as that of the first coating) was applied to all the brushes. This second coating was used to further secure the abrasive particles to the brushes. The second coating was applied in an identical manner to that of the first coating, with the exception that the rotation period at 300 RPM was extended to about 15 seconds. The resulting second coating had a dry weight of about 0.4 gram per brush. The brushes were subsequently heated in an oven set at 130°C for 45 minutes to harden the second coating. Following removal from the processing mandrel, four of the cured abrasive coated brushes were stacked one upon another and secured with a metal adaptor to make a larger radial abrasive article for testing.

Table I

| Component | Source | Parts by Weight |
|---|---|---|
| Polyurethane | ADIPRENE BL-16, Uniroyal Chemical Ltd., Elmira, Ontario, Canada | 70.37 |
| Curative | 4,4'-diaminobenzanilide, Biddle Sawyer Corp., New York, NY | 19.54 |
| Lubricant | "PM" lithium stearate, Witco Corporation, Greenwich, CT | 4.04 |
| Solvent | ARCOSOLV PM Acetate (propylene acetate monomethyl ether acetate, Arco Chemical Co., Houston, TX) | 5.65 |
| Silica fume | CAB-O-SIL, Cabot Corp., Tuscola, IL | 0.5 |

Comparative Examples A-D

Comparative Examples A-D are indicative of the state-of-the-art abrasive articles which are used to condition surfaces. Descriptions of Comparative Examples A-D are provided in Table II. Due to variation in construction, the manufacturer's recommended operating speeds varied, and are indicated in Table II.

Table II

| Example | Description | Manufacturer's Recommended Operating Speed, RPM |
|---|---|---|
| Comparative Example A | 3" (7.6 cm) CLEAN & STRIP disc, Minnesota Mining & Manufacturing Company, St. Paul, Minnesota (an abrasive coated three dimensional polymeric web). | 4,000 |
| Comparative Example B | 3" (7.6 cm) CLEAN & STRIP XT disc, Minnesota Mining & Manufacturing Company, St. Paul, Minnesota (an abrasive coated three dimensional polymeric web more dense than that of Comparative Example A). | 4,000 |
| Comparative Example C | 3" (7.6 cm) NYALOX Wheel Brush Blue, Dico Products Corporation, Utica, New York (an abrasive filled plastic radial brush) | 2,500 |
| Comparative Example D | 3" (7.6 cm) Cup Flared Wire Brush (Part No. 23319) Milwaukee Brush, Menomonee Falls, Wisconsin | 25,000 |

Test Methods

Example 1 and Comparative Examples A-D were evaluated at removing paint from an automotive panel. The panel was 0.032" (0.8 mm) thick cold-rolled steel, wherein the primer was U28RWO35K (which is a polyester melamine composition), the base coat was E86KE524S Black (which is an acrylic melamine composition), and the clearcoat was E 1 26CEO 1 2 (which is an acrylic melamine composition), prepared by ACT Laboratory, Inc., Hillsdale, Michigan. The brush of Example 1 was evaluated on an electrically-driven tool operating at 25,000 RPM. The abrasive articles of Comparative Examples A-D were evaluated at their respective recommended speeds. Comparative Examples A and B were driven by a hand-held pneumatic tool, which was an AP533 straight grinder available from Astro Pneumanic Tool Co., Japan, while Example I and Comparative Example D were driven by a hand-held electrical tool, which was a Makita Die Grinder Model 906H available from Makita Company, Japan. Comparative Example C was driven by a Black & Decker 6040 1/4" (6.1 mm) VSR drill, Type 100, commercially available from Black & Decker. Each abrasive article was tested for five minutes. The paint removal rate and brush wear were measured.

Subjective ratings of abrasive article conformability (the ability of the article to reach into interior corners) and surface loading (fouling of the abrasive article surface by workpiece swarf) were also made.

For the evaluation of both conformability and surface loading, the workpiece specimen was a coupon that was prepared by folding a 0.032" (0.8 mm) thick x 5 cm wide x 33 cm long cold rolled steel sheet so that the width of the folded coupon was 3 cm, and 2 cm of the width was a double thickness. This configuration presents a step feature (which imitates a "tight" corner) to facilitate the conformability evaluation.

For the brush surface loading evaluation, the test articles were operated for two minutes against the coupon surface coated with "HEAVY DUTY SEALER 08531" nitrile rubber based sealer commercially available from Minnesota Mining & Manufacturing Company, Automotive Aftermarket Division, St. Paul, Minnesota. The results are shown in Table III.

Test Results

The brushes of Example 1 and Comparative Example D required no manual pressure to remove the paint from the panel. Comparative Examples A, B, and C, however, did require additional urging of the abrasive article against the panel to effect paint removal. The brush of Example 1 demonstrated a high rate of paint removal, superior conformability, and no loading of the abrasive surface compared to the abrasive articles of the Comparative Examples. Abrasive articles with good conformability are better at removing paint from inside comers.

Table III

| Example | Paint Removal Rate, $in^2$/5 minutes ($cm^2$/5 minutes) | Abrasive Article Wear, grams | Conformability 1=best, 3=worst | Surface Loading |
|---|---|---|---|---|
| 1 | 144 (929) | 3.99 | 1 | No |
| Comp. A | 135 (870) | 3.43 | 2 | Some |
| Comp. B | 90 (580) | 0.87 | 3 | Some |
| Comp. C | 10 (65) | 0.48 | 2 | No |
| Comp. D | 90 (580) | 0.52 | 2 | No |

Example 2

Example 2 was prepared identically to Example 1, with the same number of bristles and the same dimensions as Example 1, with the exception that the unitary brush was cut with scissors from a 0.021 inch (0.53 mm) thick extruded film of PEBAX 6333 thermoplastic elastomer (Elf Atochem, Arlington Heights, Illinois).

Example 3

Example 3 was prepared identically to Example 1 with the exception that the unitary brush was prepared by casting a molded brush having forty 2.2 cm long integral bristles, a 1.5 inch (3.8 cm) hub, a 3.0 inch (7.6 cm diameter) from an elastomeric casting resin commercially available as SG2181 from MCP Systems, Fairfield, Connecticut, followed by curing for 45 minutes at 65°C.

Example 4

Example 4 was prepared identically to Example 2 with the exception that the unitary brush was cut via a water jet cutter from a 0.021 inch (0.53 mm) thick extruded film of PEBAX 6333 thermoplastic elastomer (Elf Atochem).

The coated brushes of Examples 2 – 4 were tested by subjective evaluation to finish the recessed areas of intricately carved wood (pine). Coated brushes of all three examples provided a refined finish uniformly along and within the carved recesses.

Various modifications and alterations of this invention will become apparent to those skilled in the art without departing from the scope and spirit of this invention, and it should be understood that this invention is not to be unduly limited to the illustrative embodiments set forth herein.